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The risks of chronic exposure to ultraviolet light in laboratory environment

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Abstract

The use of ultraviolet (UV) sources in laboratories requires safety practices. For example, when the ultraviolet light of laminar flow is on, it is important that the researcher or team members do not remain in the environment. There are laminar flows that have glasses with an ultraviolet light filter, but many models do not have any protection against ultraviolet light. Thus, we measured the irradiance inside and outside two types of laminar flows without UV filter and with UV filter respectively. And calculated the radiation levels that a researcher could receive at one meter distance for one hour daily in a time interval of one year. Thus, we found that chronic exposure to UV radiation from laminar flow can cause health risks. And we concluded that all laboratories must adopt safety measures, for example does not allow the presence of people during the disinfection stage of laminar flow with UV light.

Keywords: Ultraviolet health risks; Laminar flows without UV; Acute exposure to ultraviolet; Chronic exposure to ultraviolet

1. Introduction

Currently, there are no workplace related rules and regulations set by Occupational Safety and Health Association (OSHA) in regard to UVC environmental health and safety. [1]. Like this there are many applications for ultraviolet field lights, for example environmental decontamination, water treatment and medical applications [2.3,4].

Thus, ultraviolet (UV) radiation is known to play a significant role in the development of cancer in skin. Because of this, exposure precautions are recommended when using UVC light. [5]. For example, a dose of approximately 8 J/cm2, which corresponds to the UVA dose received approximately within 1 hour on a sunny summer day in Finland [6].

The UV range of the electromagnetic radiation spectrum extends from 10 nm to 400 and a major part of solar UV radiation which reaches the earth's surface consists primarily of UVA radiation (90–99%) with the minor component of UVB radiation (1–10%) nm.

Thereby, UV spectrum as shown is separated into four parts: UVA (315 nm to 400 nm), UVB (280 nm to 315 nm), UVC (200 nm to 280 nm) and UV Vacuum (100 nm to 200 nm) [5]. Decreasing wavelengths correspond with higher frequency radiation and a higher amount of energy per photon.

Recently published studies have demonstrated that UVA radiation can modulate a variety of biochemical processes, some of which are involved in the malignant transformation of skin [7,8] and mutagenesis [9,10].

UVA is known to cause severe oxidative damage via reactive oxygen species (ROS) [11], which can damage lipids [12], DNA [13] and induce apoptosis [14,15]. UVA may also play a significant role in the induction and development non-

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melanoma and melanoma skin cancers [10, 16, ,17, 18,19]. UV light is generally used to disinfect environments [20] and in some cases for research purposes, such as in our laboratory. So, it is important to establish safety norms and standards in environments where there is ultraviolet radiation.

Therefore, to find out if chronic exposure to laboratory UV can cause health risks, we measured the irradiance inside and outside two types of laminar flows; with UV filter (Figure 1A) and other model which have a UV filter, but part of the glass is permanently open, which allows UV radiation to escape (Figure 1B) (Table 1).

2. Material and methods

2.1. Germicidal lamp

UV-C 30W tubular ultraviolet germicidal lamp for disinfection and sterilization.30W GERMICIDE lamp. Power: 30W. Model: TUV-30W PHILIPS. Base: G13. Bulb: T8. Total Length: 908.8 (max) mm. Diameter: 28 (max) mm. Main application: disinfection. Useful Life: 9000 h. Brand: Philips. Emits wave UV radiation with a peak of 253.7 nm (UV-C) with germicidal action.

2.2. Laminar flows

The radiation dosage measurements were made in two types of laminar flow, equipped with the same type of UV lamp. A model with a UV filter on the glass, from the brand Pachane® Pa 610, lamp height 52 centimeters (Figure 1 A). And a model without UV filter from the SOLUFIL®, model 288, lamp height 46 centimeters (Figure 1B).

A	B

Figure 1 (A) model with a UV filter on the glass. (B) model without UV filter.

2.2.1. Mathematical formula to calculate the radiation dosage

To calculate the UV radiation dosage as a function of time, the following mathematical formula was used:

$$\text{Dose}\left(\frac{\text{mJ}}{\text{cm}^2}\right) = \text{irradiance}\left(\frac{\text{mW}}{\text{cm}^2}\right) * \text{time (s)}$$

2.3. Spectrum detector

Firstly, all environmental lights were turned off, only the internal UV of the flow remained on. To measure the wavelengths UVC 250nm, UVB 280nm and UVA 365nm was used a spectrum detector FieldMate Laser Power Meter. COHERENT (Figure 2) below.

Figure 2 Adjustment of spectrum detector

3. Results and discussion

The laminar flow, which has glass with UV filter, is efficient in reducing the UVC and UVB spectrum radiation that escapes into the laboratory environment (Figure 1 A) and (Table 1 A). For example, irradiance at a distance of one meter of UVC had an average of 0.0μW (Table 1 A), while at the same distance from the flow without UV filter (Figure 1 B), average measurements were UVC 4.6 μW, UVB 3.8 μW and UVA 2.4 μW (Table 1B). However, differences in irradiance between the lamps of the two laminar flows can be attributed to the time of use of the lamp and the height of lamp on each device, contributes to the scattering of radiation (Table 1). For example, exposure without security protection for one hour a day and for 150 days a year in an environment with UV laboratory light, can lead to a dose of 27 J/cm^2 of UVC, 30 J/cm^2 of UVB and 15 J/cm^2 of UVA (Table 1B).

Table 1 Laminar flows radiation

	Wavelengths	Inside (μW)	outside the glass(μW)	Outside 1m distance (μW)
Laminar flow with radiation filter				
A	UVC 250nm	21.3/26.3/26.2/52.8	0.0/0.0/0.0/0.0	0.0/0.0/0.0/0.0
	UVB 280nm	64.1/36.5/27.5/17.3	0.0/0.0/0.0/0.0	0/0/0.0/0.0/0.0
	UVA 365nm	14.1/23.0/36.1/42.8	3.8/2.9/3.3/3.4	0.72/0.75/0.73/0.73
Laminar flow without radiation filter				
B	UVC 250nm	51.1/ 60.1/65.0/58.0	4.01/9.28/6.06/8.2	7.6/3.5/3.6/3.7
	UVB 280nm	34.2/73.3/ 72.7/ 58.8	9.8/7.8/9.2/4.8	3.7/3.6/4.1/3.8
	UVA 365nm	20.7/40.4/54.2/61.5	5.6/3.92/4.1/4.62	2.1/2.8/2.3/2.4

These doses in specific wavelengths do not appear to high however the UV range of the electromagnetic radiation spectrum extends from 10 nm to 400 nm, so UV lights has health risk (Table 2) [7].

In older laminar flows, see (Figure 1B), which do not have a safety system, it is possible the UV light to remain on, without the researcher noticing, so the doses received would be quite high, see measurements outside the glass in (Table 1B). Depending on the wavelength and time of exposure, UV radiation may cause harm to the eyes and skin (Table 2) [5,7,8,21].

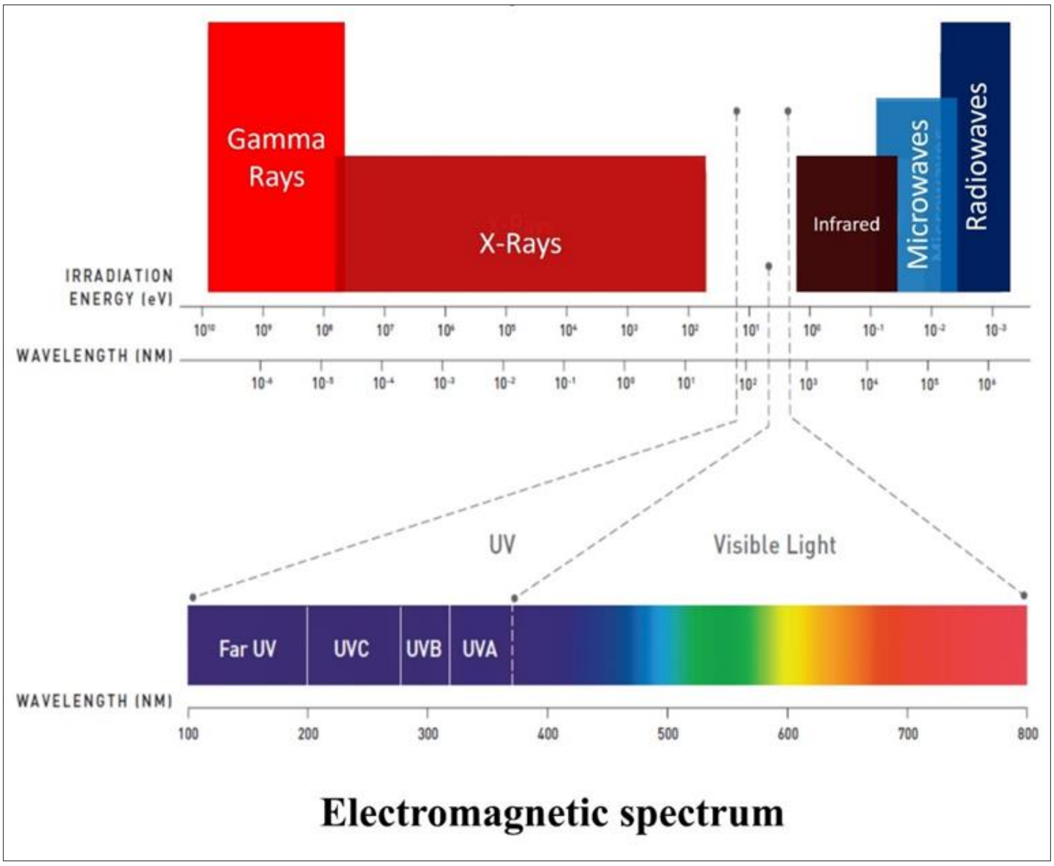

Figure 3 The UV lights occupy a band of the invisible electromagnetic field, with wavelength characteristics capable of interacting even with cellular genetic material.

Table 2 UV prolonged exposure

Band	Wavelength	Primary visual hazard	Other visual hazard	Other hazards
UVA	315 - 400 nm	Cataracts of Lens		Skin Cancer; Retinal Burns
UVB	280 - 315 nm	Corneal Injuries	Cataracts of Lens; Photokeratitis	Erythema; Skin Cancer
UVC	100 - 280 nm	Corneal Injuries	Photokeratitis	Erythema; Skin Cancer

UV bands versus health risk

Regarding the biological effect of UV light, for example UVB has often been noted for its harmful effects on human skin, however each of the UV bands: UVA, UVB and UVC have a potential for damage (Table 2). Adverse health effects that may occur include erythema, photokeratitis, retinal burn, cataracts and others [21]. The (Table 2) summarizes these effects.

The shorter UVC wavelengths are typically absorbed in atmosphere (Figure 3), and thus are thought to have less long-term damaging effects on human tissue, as shown in (Table 2) [22 , 23]. However, prolonged direct exposure to chronic doses (Table 1) of UVC light has caused eye and skin damage (Table 2) [24]. Because of this, exposure precautions are recommended when using UVC light. Thus, UV light has a known impact on human tissue (Table 2).So, the scattering increases with decreasing wavelength (Figure 4) [25, 26, 27].

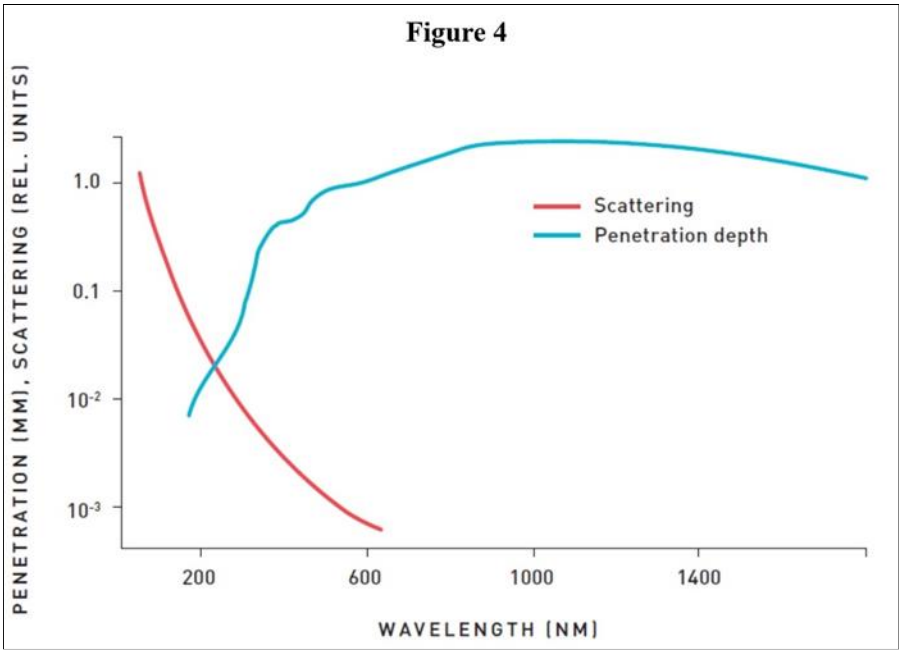

Figure 4 Impact of UV light on human tissue. In blue it is represented the penetration spectrum of light and UV radiation into human tissue. In red is represented the scattering increases with decreasing wavelength. Relative units Y axis and wavelength X axis. Nanometers (NM)

For example, acute exposure at high levels of UVC include redness or ulceration of the skin. For chronic exposures, there is also a cumulative risk, which depends on the amount of exposure at doses measured in (Table 2). Thus, the long-term risk includes premature aging of the skin and skin cancer [28].

Therefore, even a few minutes' exposure to the UVC radiation, at the doses found in (Table 1), can result in photokeratisis and conjunctivitis. Both conditions through repetitive damage can cause premature aging of ocular structures, cataracts and blindness (Table 2). [26, 29]. For example, Zuclich (1989) reported acute cataract induction by exposure to 337nm laser, in small dose of 1 J cm^2 [30]. Like this, ultraviolet light can accelerate diseases linked to the aging process [31]

Thus, it is important to use Personal Protective Equipment (PPE). UV radiation is easily absorbed by clothing, plastic or glass. Once absorbed, UV radiation is no longer active. When working with UV radiation during maintenance, service or other situations, personal protective equipment covering all exposed areas is recommended [32].

Even in small spaces, intelligent organization of UV sources can be carried out. Like this, we can see in the (Figure 5) three ways of organizing laminar flows: contraposed, juxtaposed or tandem respectively. It is important that areas in front of UV light have walls or panels that can absorb the radiation, and that there is no movement of people during the time that UV is on.

In adjacent areas warning labels should be placed outside access panels and doors to the UVC source as well as panels or doors where UVC radiation may penetrate or be reflected. This way, UVC exposure can be reduced adopting the contraposed arrangement and through product safety controls (Figure 5).

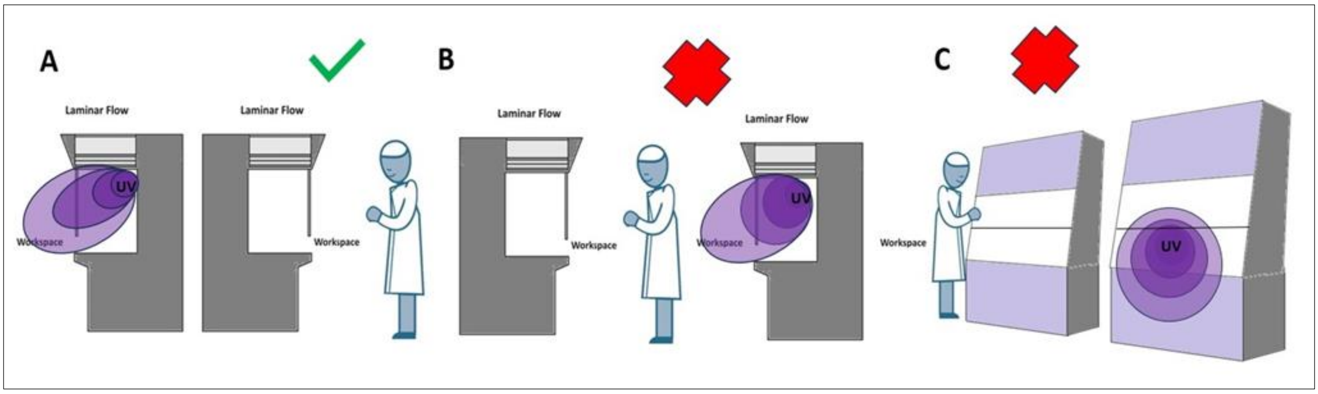

Figure 5 Ways of organizing laminar flows: (A) contraposed, (B) juxtaposed or (C) tandem. (A) is the correct way to organize UV sources. (B-C) are very common but incorrect ways as they expose other people to UV sources

4. Conclusion

Improvement of security practices in the laboratory environment contributes to society, avoiding diseases such as eye and skin cancer, burns and premature aging due to chronic exposure to ultraviolet radiation.

The difficulty of organizing the arrangement of laminar flows in small spaces is common. Furthermore, laboratories have the challenge of maintaining overcrowded environments with researchers and employees.

Thus, personal safety training is important so personnel working with UVC fixtures or near UVC installations should be provided with training on health and safety topics, handling and maintenance of UVC sources, and first aid response after exposure to UVC light.

Compliance with ethical standards

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